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ANALYSIS OF MATERIAL MANAGEMENT IN RESIDENTIAL BUILDING PROJECTS IN KERALA BYINVENTORY CONTROL TECHNIQUES

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Abstract - *In construction sector, material management plays major role for effective and timely completion of the project. The cost of project increases when the planning, material identification and material management system is poor. Shortage and deficiency in storageof material will cause losses in labour productivity. A good material management system inconstruction site can help to avoid the delay and cost variations in construction projects. This improves planning, higher labour productivity, proper schedules and lower project costs. The purpose of the study is to find the problems in material management in construction sites which causes the increase in rate of construction and suggest remedial measures for them by using surveys and simple software's. Conventionally ABC analysis is used to find quantity and importance of materials procured for the project and the variationin planned cost and actual cost respectively.*

***Key Words*: Material management, Inventory control techniques, A-B-C analysis.**

1. INTRODUCTION

Materials management is the process of planning, executing and controlling field activities in construction. Materials management aims to ensure that construction materials are available at their point of use when needed.. Materials management is the system for planning and controlling all of the efforts necessary to ensure that the correct quality and quantity of materials are properly specified in a timely manner, is obtained at a reasonable cost and most importantly are available at the point of use when required. Thus Materials management is an important aspect in project management. Materials represent a major expense in a construction project, so minimizing procurement costs improves opportunities for reducing the overall project costs. Poor materials management can lead to increased costs during construction. Efficient material management can result in substantial savings in project costs. Too often construction projects suffer from budget overruns, delays, and claims. A properly implemented materials management program can achieve the timely flow of materials and equipment to the job site, and thus facilitate improved work face planning, increased labor productivity, better schedules, and lower project costs.

1.1 Factors Related With Material Management

There are many factors within the scope of material management and each of these factors can give rise to potential problems. The more factors are divided, the more potential problems that exist.

Different stages of material management are:

a) Planning and Scheduling
b) Monitoring and Controlling
c) Organization and Personnel
d) Procurement
e) Delivery
f) Storage and Storage facilities
g) Usage
h) Surplus and Waste control

a) Planning and Scheduling

Planning is the first and important process for every project. Material planning, which is a key function of material management, is closely linked with project planning and control set- up. Planning the entire material program is essential to meeting the project timetable. Indeed, planning and scheduling are significant in terms of increasing productivity, profit and facilitating the timely completion of construction projects.

b) Monitoring and Controlling

Monitoring and Controlling of all construction activities in material management are conducted to ensure the right materials with the exact quality are available at the righttime and place suitable for minimum cost construction process. It is a step in which facilities, personnel, resources and capital are monitored and controlled to a significant impact on the operations of construction projects.

c) Organization and personnel

Material management process is organized in such a way that it allows for integralplanning and coordination of the flow of materials, in order to use the resources optimally and to minimize costs. The organization must be designed to provide for the timely performance of the work, with material personnel located at an appropriate level of project management and influence the decision-making process.

d) Procurement

Primary investigations for developing sources for procurement of materials are made by floating enquiry indents. It is processed by the material procurement responsiblepersonnel for inviting quotations with samples of materials where applicable.

e) Delivery

Delivery in terms of organizing the movement of vehicles, people and materials ensures the efficient use of workforce and production or process in construction projects. The routing of materials is one of the main causes which affect cost and time during construction stage.

f) Storage and Storage facilities

Material storage can be defined as the provision of required space, protection and control of building materials and components held on site during the construction process. A good and systematic storage of materials provides better management of materials in construction.

g) Usage

Usage of materials is the facilitation that provides for their movement and placement. The construction industry uses a variety of building materials for different aspects of a home build. Architects consult with structural engineers on the load-bearing capabilities of the materials with which they suggests.

1.2 Significance of Material Management Techniques

It was referring to the various functions of materials management, coordination of various departments of manufacturing enterprises. Once the material procured and brought by the organization, its value continues to increase other costs of materials required for the sorting, carrying materials in inventory, maintenance and management costs must be allocated to the cost of materials before entering into a product or converted to other form. In order to save the cost of all the materials Company's has taken a clear method to determine the amount of material is ordered, the number is stored as inventory and in-process inventory. In order to reduce the cost of materials and other costs in a project, there must be effective and efficient management of materials technology; it must be dynamically adjusted with changes in demand and production.

1.3 Purposes of Material Management

- Efficient material planning
- Buying or purchasing
- Procuring and receiving
- Storing and inventory control
- Stock and waste control
- Supply and distribution of material
- Quality assurance
- Good supplier and customer relationship
- Improved departmental efficiency
- Reduce the cost of project
- Timesaving
- Achieve economy in project

To fulfill all these purposes, it is necessary to establish harmony and good co- ordination between all the employees of material management department and this department should have good co-ordination with the other departments of theorganization to serve all production centres.

1.4 Objectives

The objective of the paper is to study the different material management procedures practiced currently in local construction projects. This study will generate a list of root causes for ineffective material management that can be used as a benchmark to control the existing and future projects. Furthermore the most concerning issues like cost overrun and delay in terms of project delivery and its relation with the current material management practice will reveal the weakness in the current material management practices to the stakeholders. Apart from this research being useful to the field professionals, this study will be valuable for the academicians too. As this study will serve as a support of what the past researchers have written about material management in construction projects. Furthermore it will also provide information for further researchers who are willing to investigate on this particular or similar case.

2. LITERATURE REVIEW

Literature review is usually done to understand the topic, identification of the problem and the suitable suggestions given by various researches in their paper. Various researches carried out in the material management and inventory management is studied to know the problems faced in the industry across the world. It helps to find out the different possible solution that we can obtain from literature study and understand its meaning from the below listed papers.

SantuKar *et.al* (2020) conducted a study on effect of material management issues on the schedule and cost performance of construction projects. And found that improper delivery of materials is the most critical factor disrupting projects' schedule and cost performances. Delivery of material at the wrong time and incorrect delivery cause problems in construction projects. Delivery of lesser quantity and higher quantity ofmaterials has the same effects as the late and early arrival of material, respectively. Inadequate planning of the materials was found to be the second most critical factor. Lack of information and communication was the third most critical factor. Low usage of information technology is also a problem in material management. Financial issues in procurement placed fourth.

Carlos H. C *et.al* (2015) did a study on material management in construction industry. With proper planning and true system integration and co-ordination, material shortages can be identified well in advance of when they are needed, and such problems can be corrected in sufficient time to support the construction forces to meet the project schedule. The quality of construction materials, fabrication, and on-site services continues to be of critical importance in determining the success of a construction project

H. Randolph Thomas*et.al* (2015) studied about the fundamental principles ofsite material management. Several principles are important as they relate to transporting materials from the storage or staging areas to workface areas. The first relates to the projects with below grade excavations such as basements. The use of earthen ramps should be avoided. Because these often impede the completion of basement walls that may in turn affect the entire project schedule. An economic analysis may be justified.

Georgekutty*et.al* (2012) had undergone a study to find out the causes for incompletion of project. A questionnaire survey was conducted in Kerala. From his research, the main delay or incompletion of project could be solved by proper pre- planning and scrutinize material procurement frequently to cut off the exceeding ofproject cost.

A M Belay *et.al* in 2017conducted a study on the Cost deviation in construction projects be. In this research some focused only on cost deviation and others linked cost with other attributes (e.g. with delay) and tried to investigate the overall project performance. However, very limited research carried out on the correlation between cost deviation and the total construction time.

2.1 Inventory Management

Tom Jose (2013) made a comparative Study in the Analysis of Inventory Control Techniques. The various types of analysis studied in this paper were EOQ analysis, ABC analysis and FSN analysis. From the analysis he found that there was a difference in the EOQ & no. of unit purchased which means EOQ was practice in the company. Also, the company maintained low percentage in fast moving items when compared to the slow moving inventories on using controlling techniques which was not preferred.

Sindhu (2014) made performance analysis study on Inventory Management System in Construction Industries in India. The main aim of the study was to evaluates the inventory management control approved and the efficient use of inventory at the construction site. Questionnaire survey was conducted at first in various construction companies and then those results were analyzed by using Statistical Package for Social Sciences (SPSS). ABC analysis is the conventional method to classify the inventories and the case study of a company was collected. The model dealt was with uncertain demand and availability of supply.

Monika RamdasNanaware*et.al* (2017) studied about application of inventory control technique in construction and found that the inventory control very useful to control the cost of a any construction project. The paper also stated that the inventory management can be done effectively by using ABC analysis as well as EOQ. The implementation of ABC analysis gives the distribution of A, B and C type materials. This distribution of materials represents the economic importance of materials. EOQ gives the results of right quantity of orders at the right time. It avoids the delays in supply of material and also avoids wastage of materials.

2.2 Relative Importance Index

Muhammad Rooshdi*et.al* (2018) done a study on Relative Importance Index of sustainable design and construction activities criteria for green highway. The relative index analysis was used to determine the relative ranking of the criteria and is transformed from all the numerical scores of the identified criteria. These ranking enabled the researcher to cross-compare the relative importance of the criteria as perceived by respondents.

N S Azman*et.al* (2019) conducted a study on Relative importance index in ranking of quality factors on industrialized building system projects. A total of one hundred and nine (109) factors were classified into three related group in this project as: design, production, and construction. The top important factors were identified using the ranking result by Relative Importance Index.

3. METHODOLOGY

The research approach adopted in this project is the combination of both the qualitative and quantitative methodologies Study first collected the materials like literature review and latest published papers related to material management, in many literature reviews ABC analysis is commonly used for material management. Methodology of the study is as follows.

1. Literature gathering
2. Prepare literature review
3. Identify material management processes and root causes in ineffective materialmanagement in other countries to formulate the questions
4. Preparation of the questionnaire
5. Distribute the questionnaire
6. Identify the targeted response group
7. Data collection
8. Grouping of Material Management Issues
9. Data analysis
10. Result and discussion.

3.1 Relative Important Index

Relative Importance Index (RII) is used to determine the relative importance of quality factors involved. The points of likert scale used are equal to the value of W, weighting given to each factor by the respondent. The Relative Importance Index (RII) is calculated by equation

$$RII = \Sigma W / (A*N)$$

Where, W is the weighting given to each factor by the respondents (ranging from 1 to 5), A is the highest weight (i.e. 5 in this case), N is the total number of respondents. Higher the value of RII more important the cause of delays.

3.2 Cost Performance Index

Cost Performance Index (CPI) was calculated by using estimated and actual cost of materials as

CPI = BUDGET COST / ACTUAL COST

The variation in the actual cost from budgeted cost results in the deviation of CPI value from 1. The materials which show cost variation according to CPI value were selected for further analysis and the cost variation of different materials were studied. Some materials are omitted from further analysis since they does not show a considerablevariation in cost according to CPI value.

3.3 ABC Analysis

The ABC analysis classifies the material item based on Annual Usage Value of items in order to determine its priority among plenty of material items. The ABC analysis is used to identifying materials that has the highest impact on overall inventory cost. In this method materials are divided into 3 Groups. i.e. A, B and C Groups. The class A materials requires the highest attention as they contribute to 7% of the cost, B Class materials which require medium attention contribute to 20% of the cost and materials in class C which require the least attention contribute to 10% of the cost.

Methodology Adopted for ABC analysis:

1. List all the materials items used in the project along with unit price and quantityconsumed annually.
2. Compute the Annual Usage Value (AUV) of each material item.
3. Arrange the items in the descending order of AUV and compute the cumulative percentage units consumed and cumulative percentage of AUV for each item.
4. Classify them according to AUV

4. RESULT AND DISCUSSION

4.1 Phase 1 Data Collection And Analysis

Survey questions were given out to different construction firms and experienced personals. The factors were classified into 5 categories and the respondents were requested to rate the factors according to the options given from 1 to 5 where,

5 - Very frequently occurring
4 - Frequently occurring
3 - Occur some of the time
2 - Occur rarely
1 - Occur very rarely

Table -1: Relative Importance Index and Overall Ranking of all Factors

Rank	Factor	RII
1	Fluctuation in the cost of raw materials	0.851
2	Fluctuation in labor cost	0.829
2	Additional work due to changes in design	0.829
4	Supply and demand of building materials	0.825
5	Design changes	0.818
6	Wrong method of estimation by quantity surveyor	0.8
7	Poor site planning	0.796
8	Unsuitable locations for storage	0.792
9	Inadequate coordination among design team	0.785
10	Inflation	0.781
11	Wastage of building materials by labors	0.777
11	Additional work due to errors in design	0.777
13	Communication problem between labors and supervisors	0.77
13	Transportation cost	0.77
15	Inadequate production of building materials	0.755
15	Inadequate equipment	0.755
15	Design team experience	0.755
15	Labor availability	0.755
19	Clients financial capacity	0.748
20	Inadequate infrastructural facilities	0.740
21	Construction design complexity	0.725
21	Aesthetics	0.725
23	Delay in payment of construction laborers	0.718
24	Lack of discipline among laborers	0.711
25	Disposal cost	0.666
25	Health and safety	0.666
27	Shortage of building materials on site	0.618
28	Recycle cost	0.614
28	Use of local materials	0.614
30	Scarcity of building raw materials	0.592
31	Interest rate	0.514
32	Local taxes and charges	0.392

4.2 Phase 2 Data Collection And Analysis

Table -2: Cost Performance Index of Materials in Site 1

Materials	Estimated Cost	Actual Cost	Cost Performance Index
Cement (bag)	284000	304000	0.934211
Sand (cu ft)	109620	124200	0.882609
Coarse aggregate (cu ft)	103955	108000	0.962917
Steel (kg)	348936	359600	0.970345
Brick / Laterite (no)	177652	181700	0.977722

Plumbing materials	220000	221500	0.993228
Electrical appliances	210000	212000	0.990566
Tile (sq ft)	187760	192000	0.977917

Table -3: Cost Performance Index of Materials in Site 2

Materials	Estimated Cost	Actual Cost	Cost Performance Index
Cement (bag)	391500	405000	0.966667
Sand (cu ft)	130900	140000	0.935
Coarse aggregate (cu ft)	77400	81700	0.947368
Steel (kg)	206325	214200	0.963235
Brick/ Laterite (no)	179100	182250	0.982716
Plumbing materials	200000	200000	1
Electrical appliances	190000	190000	1
Tile (sq ft)	236250	241500	0.978261

Table -4: Cost Performance Index of Materials in Site 3

Materials	Estimated Cost	Actual Cost	Cost Performance Index
Cement (bag)	347100	354900	0.978022
Sand (cu ft)	149445	153000	0.976765
Coarse aggregate (cu ft)	146430	148500	0.986061
Steel (kg)	352780	359600	0.981034
Brick/ Laterite (no)	276552	282900	0.977561
Plumbing materials	342500	343000	0.998542
Electrical appliances	394000	395000	0.997468
Tile (sq ft)	487500	494000	0.986842

Table -5: Cost Performance Index of Materials in Site 4

Materials	Estimated Cost	Actual Cost	Cost Performance Index
Cement (bag)	240000	252000	0.952381
Sand (cu ft)	93600	98800	0.947368
Coarse aggregate (cu ft)	81000	83250	0.972973
Steel (kg)	160485	162500	0.9876
Brick / Laterite (no)	145000	147500	0.983051
Plumbing materials	155000	156000	0.99359
Electrical appliances	123000	123000	1
Tile (sq ft)	150000	154000	0.974026

Table -6: Cost Performance Index of Materials in Site 5

Materials	Estimated Cost	Actual Cost	Cost Performance Index
Cement (bag)	304000	320000	0.95
Sand (cu ft)	90750	99000	0.916667
Coarse aggregate (cu ft)	72000	76000	0.947368
Steel (kg)	263250	269750	0.975904
Brick / Laterite (no)	148780	154800	0.961111

Plumbing materials	210000	214000	0.981308
Electrical appliances	190000	192000	0.989583
Tile (sq ft)	225625	229900	0.981405

Table -7: Cost Performance Index of Materials in Site 6

Materials	Estimated Cost	Actual Cost	Cost Performance Index
Cement (bag)	350000	364000	0.961538
Sand (cu ft)	130500	137250	0.95082
Coarse aggregate (cu ft)	128000	132000	0.969697
Steel (kg)	357360	360000	0.992667
Brick / Laterite (no)	251550	253700	0.991525
Plumbing materials	282500	283000	0.998233
Electrical appliances	326500	328000	0.995427
Tile (sq ft)	330000	333300	0.990099

Table -8: ABC Analysis of Materials in Site 1

Material	Estimated Rate	Percentage of Rate	Cumulative % of Rate	Class
Steel	348936	28.79098	28.79098	A
Cement	284000	23.43306	52.22404	A
Flooring Material	187760	15.49222	67.71626	A
Brick / Laterite	177652	14.6582	82.37446	B
Sand	109620	9.044831	91.41929	B
Coarse Aggregate	103995	8.580707	100	C

Table -9: ABC Analysis of Materials in Site 2

Material	Estimated Rate	Percentage of Rate	Cumulative % of Rate	Class
Cement	391500	32.05141	32.05141	A
Flooring Material	236250	19.34137	51.39278	A
Steel	206325	16.89146	68.28425	A
Brick / Laterite	179100	14.6626	82.94685	B
Sand	130900	10.71655	93.6634	B
Coarse Aggregate	77400	6.336601	100	C

Table -10: ABC Analysis of Materials in Site 3

Material	Estimated Rate	Percentage of Rate	Cumulative % of Rate	Class
Flooring Material	487500	27.7019	27.7019	A
Steel	352780	20.04652	47.74842	A
Cement	347100	19.72375	67.47217	A
Brick / Laterite	276552	15.71491	83.18708	B
Sand	149445	8.492124	91.6792	B
Coarse Aggregate	146430	8.320799	100	C

Table -11: ABC Analysis of Materials in Site 4

Material	Estimated Rate	Percentage of Rate	Cumulative % of Rate	Class
Cement	240000	27.58351	27.58351	A
Steel	160485	18.44475	46.02826	A
Flooring Material	150000	17.23969	63.26796	A
Brick / Laterite	145000	16.66504	79.933	B
Sand	93600	10.75757	90.69056	B
Coarse Aggregate	81000	9.309435	100	C

Table -12: ABC Analysis of Materials in Site 5

Material	Estimated Rate	Percentage of Rate	Cumulative % of Rate	Class
Cement	304000	27.52613	27.52613	A
Steel	263250	23.83636	51.3625	A
Flooring Material	225625	20.42955	71.79205	A
Brick / Laterite	148780	13.47151	85.26356	B
Sand	90750	8.217094	93.48065	B
Coarse Aggregate	72000	6.519348	100	C

Table -13: ABC Analysis of Materials in Site 6

Material	Estimated Rate	Percentage of Rate	Cumulative % of Rate	Class
Steel	357360	23.09407	23.09407	A
Cement	350000	22.61844	45.71251	A
Flooring Material	330000	21.32596	67.03847	A
Brick / Laterite	251550	16.2562	83.29467	B
Sand	130500	8.433447	91.72811	B
Coarse Aggregate	128000	8.271887	100	C

5. CONCLUSIONS

- The study makes us to understand there is no proper material management practice adopted which is leading to increase total inventory cost and improper material handling.
- The ABC analysis shows that:
  1. Class A items contribute about 70% of the total material cost. It is found that Cement, Steel and Flooring materials belong to this class.
  2. Class B items contributes 20% of the total material cost. Blocks, and Sand belongto this class.
  3. Class C items contribute 10% of the total material cost. It is found Coarseaggregate belong to this class among the selected items.
- In case of the considered sites and considered materials, Class A material causes an average of 61.77% of the deviation in estimated cost where the deviation for Class B items were about 29.42% and that for Class C items were found to be an average of 8.72%.
- This shows that high care should be given to Class A materials to reduce the increase in cost, moderate care for Class B materials and Class C materials are the type which requires the least care.
- Apart from the factors that are inevitable, like Fluctuation in the cost of raw materials, Fluctuation in labour cost, Additional work due to changes in design etc. the most commonly occurring reasons for increase in cost of project according to the survey are,
  1. Supply and demand of building materials
  2. Wrong method of estimation by quantity surveyor
  3. Poor site planning
  4. Unsuitable locations for storage
  5. Wastage of building materials by labors

6. RECOMMENDATIONS

- Owners involving directly in construction work such as holding tendering directly may be avoided. It is better to assign these jobs to the consultant or a representative who is familiar with the technical issues.
- A construction manager should be hired for jobs such as selecting the suitable construction methods or materials, cost and time management, observing the construction process and organizing the contracts.
- Having a fulltime supervisor in the project site will help to prevent the occurrence of rework or to make the wrong implemented works correct on time.
- Occurrence of rework can be avoided by making the selection of contractors considering the technical competency of the contractors. Most of the time the best contractor to select is not the one who offered the lowest price since there are hidden costs such as rework cost with them.
- Making changes in the plans or the materials used should be avoided by the owners as much as possible.
- Proper and clear contracts must be written to make the missions and responsibilities of contractors, consultant, and management team.
- Do not utilize substandard materials in construction.
- Avoid of buying more or less amount of bars than that are needed for construction.
- Excavation walls should be protected from falling by constructing a proper structure.
- Define the excavation area clearly before excavation.
- Hiring trained workmanship may fasten the work and also nullifies the chances of defective work.

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